

**T07D01 – (7.2) Position of Equilibrium**

Name .....

1. 7.2.1 Deduce the equilibrium constant expression ( $K_c$ ) from the equation for a homogeneous reaction. (3)

a. What is the general equation of an equilibrium constant,  $K_c$ ? (AKA, the equilibrium law)

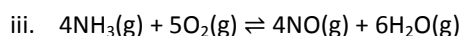
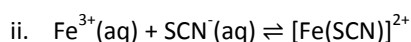
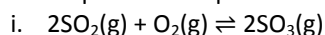
- b. For the production of ammonia ( $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ ) @500°C, give the expression for  $K_c$  during each of the following experiments:

	$[N_2] \text{ mol dm}^{-3}$	$[H_2] \text{ mol dm}^{-3}$	$[NH_3] \text{ mol dm}^{-3}$
Exp. 1	0.992	0.763	0.157
Exp. 2	0.299	1.197	0.203
Exp. 3	2.59	2.77	1.82

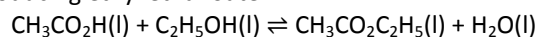
- c. Show the equilibrium equation and equilibrium constant expression for both the forward and reverse reactions of the formation of HI(g) from its elements:

- d. What happens to the value of  $K_c$  when the reaction is reversed? How is one calculated from the other?

- e. Write the equilibrium expression for the following reactions



- f. The following reaction is an esterification reaction producing ethyl ethanoate:



The value of  $K_c$  for this reaction is 4.0 @ 25°C

2. 7.2.2 Deduce the extent of a reaction from the magnitude of the equilibrium constant. (3)

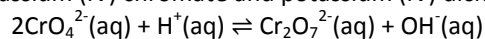
- a. How does the magnitude of  $K_c$  for the production of hydrogen halides of Cl and I compare? State how the magnitude of  $K_c$  sets the equilibrium in general:

- b. What are the relative values of  $K_c$ ?

$K_c < 10^{-10}$	$K_c = 0.01$	$K_c = 1$	$K_c = 100$	$K_c > 10^{10}$

- c. What is  $K_c$  NOT altered by?

- d. For the equilibrium between potassium (IV) chromate and potassium (IV) dichromate the equation is



state the equilibrium expression and explain how we can study this reaction:

3. 7.2.3 Apply Le Chatelier's principle to predict the qualitative effects of changes of temperature, pressure and concentration on the position of equilibrium and on the value of the equilibrium constant. (2)

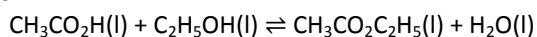
a. State Le Chatelier's Principle (you do not need to memorize this):

b. What does this principle really mean?

- c. What are the effects on the position of equilibrium and the value of  $K_c$  when the following changes in environment take place?

Change Made	Effect on position of equilibrium	Value of $K_c$
[conc] is changed		
Pressure		
Temperature		
Catalyst		

- d. For the esterification reaction of



Explain what happens when water is removed to the reaction at equilibrium:

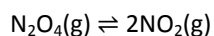
- e. The production of Ammonia is very important, what happens when the concentration of  $\text{N}_2$  is changed?

Equilibrium Reaction	When Excess $\text{N}_2$ is added

- f. In general, what happens when the [reactant] or [product] is increased?

- g. Explain how Le Chatelier's principle accounts for a change in pressure (due to volume change):

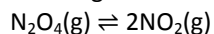
- h. When dinitrogen tetroxide is decomposed the reaction is as follows:



Explain what happens when a change in pressure occurs and how it can be monitored:

- i. What happens to equilibrium when the temperature is changed, and why?

- j. For the same reaction of the decomposition of dinitrogen tetroxide:



How does the change in temperature effect the equilibrium, and how can it be monitored:

- k. The effect of temperature on the equilibrium is dependent on the enthalpy of reaction, complete the following table to show the relative changes:

Nature of forward reaction	Change in Temperature	Shift in the position of equilibrium	Effect on value of $K_c$

4. 7.2.4 State and explain the effect of a catalyst on an equilibrium reaction. (3)

- a. Review: explain what a catalyst is and what it does:

5. 7.2.5 Apply the concepts of kinetics and equilibrium to industrial processes. (2)

- b. Haber Process:

- i. State the use and purpose nitrogen containing compounds, list a few:

- ii. The end goal of the Haber Process is to produce ammonia, there are several steps to this process, starting with methane provide the main parts to the process:

1. What must be removed from methane? Why?

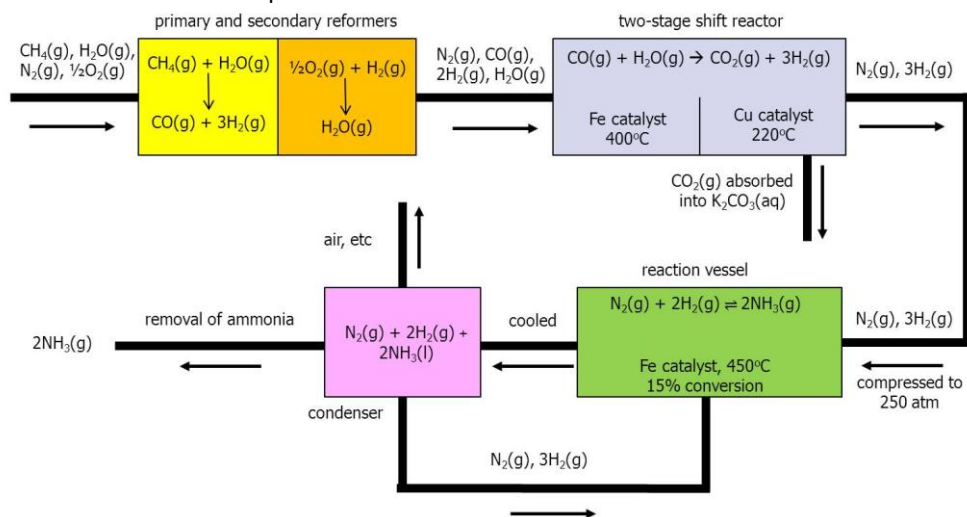
2. Methane reacts with water, provide the equation (don't forget the catalyst):

3. What must be removed after the reaction of methane?

4. What must be done to air before  $\text{N}_2$  can be added to  $\text{H}_2$ ?

5. Give the equation for the equilibrium reaction to produce ammonia:

iii. The Haber Process is presented below:



iv. According to Le Chatelier's principle what are the optimum conditions for a greater yield in ammonia, why?

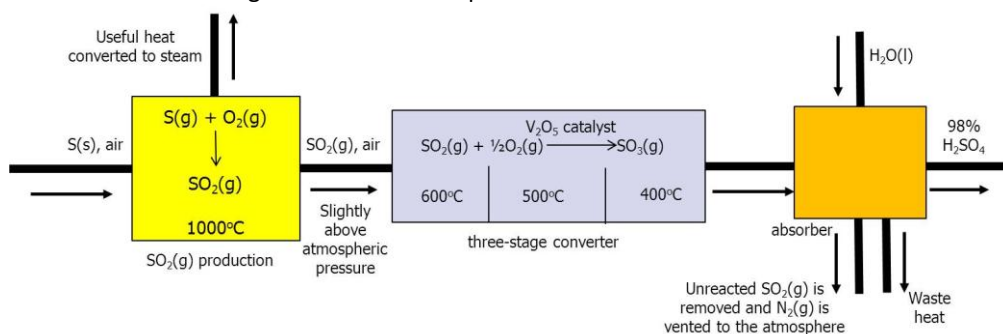
v. This is not followed, explain using pressure, temperature, and a catalyst

vi. (Haber continued) What is the catalyst used for the final step? What does chemisorption mean?

c. The Contact Process:

i. Why is the production of sulfuric acid so important?

ii. Below is a diagram of the contact process:



iii. Stage 1:

iv. State 2: state the optimum conditions based on Le Chatelier's Principle, then state what the actual conditions are, and why:

v. Stage 3: